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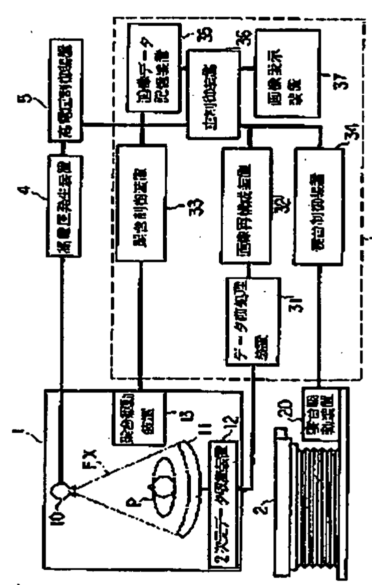
(54)【発明の名称】　コンピュータ断層撮影装置

(57)【要約】
【目的】本発明の目的は、２次元アレイ検出器を用いたヘリカルスキャン方式のＣＴで、簡易な処理でアーチファクトの少ない再構成画像を作成可能なＣＴを提供することである。
【構成】本発明は、２次元アレイ検出器１１を用いてヘリカルスキャンにより投影データを収集するコンピュータ断層撮影装置において、実際に得られた２次元状の投影データから任意に定めた仮想平面の位置に近似するＸ線パスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成することを特徴とする。



【特許請求の範囲】

【請求項１】　２次元アレイ検出器を用いてヘリカルスキャンにより投影データを収集するコンピュータ断層撮影装置において、実際に得られた２次元状の投影データから任意に定めた仮想平面の位置に近似するＸ線パスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成することを特徴とするコンピュータ断層撮影装置。

【請求項２】　前記近似投影データを同時に収集されたスライス方向に隣接する少なくとも２つの実際に得られた投影データの補間により求めることを特徴とする請求項１記載のコンピュータ断層撮影装置。

【請求項３】　前記仮想平面は前記ヘリカルスキャンの中心軸に対して傾斜する斜断面として設定されることを特徴とする請求項１記載のコンピュータ断層撮影装置。

【請求項４】　前記仮想平面を空間的に連続するように複数設定し、各仮想平面について再構成像を再構成することによりボリュームデータを得ることを特徴とする請求項１記載のコンピュータ断層撮影装置。

【請求項５】　前記ヘリカルスキャンはＸ線源が被検体に対して相対的に螺旋軌道上を移動することにより実行され、前記仮想平面を前記Ｘ線源が略１８０度回転する間の複数のＸ線パスにより描かれる湾曲面に近似する平面として設定されることを特徴とする請求項１記載のコンピュータ断層撮影装置。

【請求項６】　前記仮想平面を、半螺旋の各回転角における前記Ｘ線源のＺ座標と、前記Ｘ線源の螺旋軌道により規定される円筒と前記仮想平面とが交差する楕円のＺ座標との差の絶対値の最大値が、最小になるように設定することを特徴とする請求項５記載のコンピュータ断層撮影装置。

【請求項７】　前記仮想平面を、半螺旋の各回転角における前記Ｘ線源のＺ座標と、前記Ｘ線源の螺旋軌道により規定される円筒と前記仮想平面とが交差する楕円のＺ座標との差の二乗平均誤差が、最小になるように設定することを特徴とする請求項５記載のコンピュータ断層撮影装置。

【請求項８】　前記近似投影データは、前記Ｘ線源とＦＯＶ中心との距離を直径とする円筒と、前記仮想平面の交差する楕円上を通過するＸ線パス上のデータであることを特徴とする請求項５記載のコンピュータ断層撮影装置。

【請求項９】　前記近似投影データは、前記Ｘ線源を中心にしてＦＯＶ中心を通る円筒と前記仮想平面の交わる楕円を通過するＸ線パス上のデータであることを特徴とする請求項５記載のコンピュータ断層撮影装置。

【請求項１０】　前記２次元アレイ検出器のスライス方向の幅から換算したＦＯＶ中心でスライス方向の再構成厚みをｃとしたとき、前記Ｘ線源の１回転での被検体の相対的移動距離を略１．５ｃに設定することを特徴とする請求項５記載のコンピュータ断層撮影装置。

【請求項１１】　前記再構成は部分角再構成法を利用したものであることを特徴とする請求項１記載のコンピュータ断層撮影装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、ヘリカルスキャン方式のコンピュータ断層撮影装置（以下「ＣＴ」と略す）に関する。

【０００２】

【従来の技術】現在、被検体を透過したＸ線を検出する検出器を１次元に配列した１次元検出器を持つＣＴが一般的に普及している。そして、近年では、Ｘ線源（ソース）と検出器を連続回転させながら寝台を移動させることで、寝台と共に移動する移動座標系においてＸ線源が螺旋軌道を描いて移動するいわゆるヘリカルスキャン方式が急速に普及し始めている。さらに、１次元検出器の多列化や照射Ｘ線のコーンビーム化により、データの３次元化の実現性が模索されている。

【０００３】１次元検出器によるヘリカルスキャン方式では、Ｘ線源が螺旋軌道を移動するため、再構成断面上の投影データの大部分を線形補間処理等により近似的に補間作成することが必要である。この作成したデータを、以下、近似投影データと称する。再構成は実質的に１回転分のデータが必要になるので、例えば１０ｃｍ分の厚みを持つ領域を２ｍｍスライスデータとして欲しければ、５０回転のスキャンが必要であった。

【０００４】１次元検出器を２列設けたいわゆるデュアルスライス・ヘリカル方式は、データ収集速度が原理的に上記方式の２倍になる。これを発展させて１次元検出器を多列化することが考えられるが、列間でのＸ線パスが平行とは見做せなくなる。仮にこれを平行とみなして、単純に列毎に画像をマルチスライスとして再構成したのではアーチファクトの多い実用に耐えない画像となってしまう。これらの問題を克服する技術は現在提案されておらず、従ってこの方式では精々２倍の高速化が限度であると結論されている。

【０００５】コーンビームスキャン方式では、被検体がコーンビーム内に完全に含まれる場合には理論的に完全な再構成が可能であるが、被検体がコーンビーム内に完全に含まれない場合には、適当な再構成の解法が提案されていない。

【０００６】

【発明が解決しようとする課題】以上のように、２次元アレイ検出器を用いたヘリカルスキャン方式のＣＴで、簡易にしてアーチファクトの少ない再構成方法が存在していない。本発明の目的は、２次元アレイ検出器を用いたヘリカルスキャン方式のＣＴで、簡易な処理でアーチファクトの少ない再構成画像を作成可能なＣＴを提供することである。

【０００７】
【課題を解決するための手段】本発明は、２次元アレイ検出器を用いてヘリカルスキャンにより投影データを収集するコンピュータ断層撮影装置において、実際に得られた２次元状の投影データから任意に定めた仮想平面の位置に近似するＸ線パスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成することを特徴とする。

【０００８】
【作用】本発明によれば、実際に得られた２次元状の投影データから任意に定めた仮想平面の位置に近似するＸ線パスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成するので、２次元アレイ検出器を用いたヘリカルスキャン方式のＣＴで、簡易な処理でアーチファクトの少ない再構成画像を作成することができる。

【０００９】
【実施例】以下、本発明によるコンピュータ断層撮影装置（以下、「ＣＴ」と略す）の一実施例を説明する。図１は本実施例に係るＣＴの構成図であり、図２は図１のデータ前処理装置のブロック図である。ＣＴは、大きく架台１、寝台２、コンソール３から構成される。架台１の中心部には、円筒形の開口部が開けられ、スキャン時には被検体Ｐが寝台２に載置された状態で挿入される。なお、被検体Ｐの体軸方向に平行な水平軸をＺ軸、鉛直軸をＹ軸、Ｚ軸に直交する水平軸をＸ軸と定義する。寝台２は寝台駆動装置２０に駆動されて被検体Ｐを載置したままで移動可能に構成される。Ｘ線源１０は、高電圧発生装置４から高電圧を受けて、扇状のＸ線ビームＦＸをばく射する。この扇状のＸ線ビームＦＸの広がり角度をファン角度といい、中心軸を挟んで左右に±Ａ°、合計２Ａ°とする。典型的な例としては、ファン角度は５０°に設定されている。２次元アレイ検出器１２は、被検体Ｐを透過したＸ線を電気信号として検出する検出器を２次元状に配列してなる。Ｘ線源１０と２次元アレイ検出器１２とは、図示しない回転機構及びスリップリング機構によって、対向した状態のままで被検体Ｐの周囲を連続回転可能に支持されている。この回転は架台駆動装置１３によって駆動される。２次元アレイ検出器１２の出力は２次元データ収集装置１２で時間的に積分され、ディジタル化されて投影データとして収集される。高電圧発生装置４は高電圧制御装置５に、架台駆動装置１３は架台制御装置３３に、寝台駆動装置２０は寝台制御装置３４にそれぞれ制御される。

【００１０】２次元データ収集装置１２からの投影データは、データ前処理装置３１に送られ、まずデータ前処理部３１１で Log変換（対数変換）等の一般的な前処理を施された後、前処理後２次元投影データ記憶部３１２に記憶される。斜断面近似投影データ作成部３１３は、前処理後の投影データを使って斜断面に関する画像を再構成するのに必要な近似投影データを作成する。画像再構成装置３２は、斜断面近似投影データ作成部３１３で作成された近似投影データから画像（斜断面像）を再構成する。この再構成処理には、１８０°分の投影データから画像を再構成することが可能ないわゆるハーフ再構成処理法が採用される。この断層像データは主制御部３６を介して画像表示装置３７に送られ表示され、また画像データ記憶装置３５に送られ記憶される。主制御部３６は、高電圧制御装置５、架台制御装置３３、寝台制御装置３４を制御してヘリカルスキャンを実行する。

【００１１】次に本実施例の作用について説明する。なお、説明の便宜上、被検体Ｐと共に移動する移動座標系を規定する。この移動座標系において、ヘリカルスキャンではＸ線源１０は図３（ａ）に示すように螺旋軌道を移動することになる。実際の動きでは、Ｘ線源１０及び２次元アレイ検出器１１が連続回転しながら、寝台２により被検体Ｐが一方向に移動する。ここで、以下の説明で扱う特殊用語について定義する。

・実在投影データ；実際に２次元アレイ検出器１１の各検出器で収集された実在の投影データ

・仮想投影データ；再構成面（ここでは斜断面として定義される）の画像を再構成するために必要とされる理想的、つまり当該再構成面に含まれるＸ線パス（仮想パスという）上の投影データ。ヘリカルスキャンでは、このような仮想投影データは、一部の例外を除いて、実在しない。

・近似投影データ；仮想パスに最も近似するＸ線ビームＦＸ内のＸ線パス（近似パスという）上の投影データ。なお、この近似投影データは実在投影データとして実在する場合もあるし、実在しない場合もあり得る。実在しない場合、近似パスに近い実在投影データから補間（距離補間）により作成する。近似投影データは、Ｘ線源１０の回転角度各々について、Ｘ線源１０からのＸ線の放射方向（ファン内角度として定義する）毎に、１つずつ作成される。

【００１２】なお、ヘリカルスキャンでは、再構成に必要な複数のＸ線パスにより１枚の平面を定義できない。本実施例の特徴の１つは、Ｘ線源１０の半回転分のＸ線パス群に対して、Ｚ軸に対して傾斜する斜断面（再構成面）を設定し、この半回転分の投影データを使って画像を再構成することにある（図３（ｂ）参照）。これにより、半回転分のＸ線パス群により描かれる湾曲面と再構成面とのずれは少なく、アーチファクトの少ない画像を再構成することができる。さらに本実施例の特徴は、半回転分のＸ線パス群に対して、アーチファクトが最小に、つまり上記ずれ量を最小にする斜断面を設定し、且つ近似パスを設定することである。近似パスは、Ｘ線源１０の回転角度、ファン内角度、Ｚ位置により特定される。

【００１３】３次元のボリュームデータは、斜断面をＸ

線源１０の螺旋軌道に沿って少しずつずらしながら、再構成処理を繰り返すことにより得られる。この斜断面の移動ピッチに応じて空間分解能が変化する。例えば、図４に９０°ずつずらした斜断面の変化を示す。この方法によれば、例えば１回転で、これまで実用化されているシングルスライスあるいはデュアルスライスのヘリカルＣＴの数倍分（移動ピッチに応じて変化する）の画像を再構成することができる。

【００１４】以下に詳細に説明する。

・再構成すべき仮想平面（斜断面）の設定について

Ｘ線源１０が１８０°回転する間に移動するＸ線パス群により、斜断面が近似的に規定されることを上述したが、最も近似する上記ずれ量の最小となる仮想平面を特定する必要がある。図６にＸ線源１０（ソース）の螺旋軌道を横軸をＸ線源１０の回転角、縦軸をＺ座標として表現している。Ｘ線源１０の螺旋軌道はこのグラフ上では原点を通る１次の直線ｆsourceで示される。一方、仮想平面は、このグラフ上ではサインカーブｆplane として示される。ここでは、０°を中心に１８０°＋ファン角度２Ａ、つまり±（９０°＋Ａ）分がハーフ再構成に必要なビューとして与えられる。ｆsourceとｆplane の差の積分が小さい程、仮想平面と、Ｘ線源１０の螺旋軌道の半回転分のＸ線パス群で描かれる湾曲面とのずれ量が小さいことは容易に理解されるであろう。

【００１５】例えば、ファン角度２Ａ＝５０°とすると、９０°＋Ａ＝１１５°となるが、このとき仮想平面の傾斜角（グラフ上はサインカーブｆplane の０度での傾きに相当）と、ヘリカルスキャン時のＸ線源１０の回転に対する寝台２の相対移動速度に応じたｆsourceの傾きの比が１．０９５であるとき、両関数の差分ｄ１，ｄ２がほぼ一致する。すなわち両関数の差の絶対値の最大値（｜ｄ１－ｄ２｜）が、最小になるように、仮想平面を設定することにより、最もアーチファクトの少ない最適な仮想平面を特定することが可能である。このように両関数の差の絶対値の最大値に基づく方法の他に、両関数の差分の２乗平均が最小となるように仮想平面を設定する方法を採用してもよい。勿論、このような２つの方法に限定されるものではない。

【００１６】・近似パスの設定について

図６を参照して理解されるように、仮想平面内に含まれる仮想パスは希少であり、したがって仮想投影データは実在投影データとしてはほとんど存在しない。したがって、一定の厚みを持った扇状のＸ線ビーム内における、仮想パスとに最も近い近似パスを設定する。ここで、ファン内角度０°について考えると、図７のようにＦＯＶ（Ｆｉｅｌｄ　ｏｆ　Ｖｉｅｗ）の中心（Ｘ線源１０の回転中心に同じ）を通る仮想平面上のパスが仮想パスである。一方、近似パスは、Ｘ線源１０からＦＯＶ中心を通るパスとして与えられる。この近似パスを通る実在投影データがファン内角度０°に関する近似投影データと

される。この近似パスを通る実在投影データ存在しなければ、当該近似パスと検出器面との交点に最も近いチャンネルＡ，Ｂの２つの実在投影データから補間により近似投影データを作成する。図５に、回転角度の変化に対する近似パスの検出面の交点群の変化を太線で概念的に示す。近似パスの設定方法について、２種類の具体例を提供する。

【００１７】（１）第１の近似パスの設定方法（図８（ａ）参照）

この方法では、Ｘ線源１０の或る回転角について見ると、近似パスの検出面上への交点がファン内角度の変化に伴って「直線」で描かれることになる。上述したようにファン内角度０°の近似パスはＦＯＶ中心で仮想平面と交差するように設定される。他のファン内角度の近似パスと仮想平面との交点が、Ｘ線源１０を中心としてＸ線源１０からＦＯＶ中心までを半径とした仮想平面の僅かに扁平な楕円を描くように、近似パス群が設定される。この方法の利点は、実際の計算の煩雑度が小さいことが挙げられる。図９に、この方法による１枚の断層像を再構成するのに必要な全ての近似パスを示している。なお、図９では、Ｘ線源１０の回転角度ξは絶対角度ではなく、Ｘ線源１０が再構成に用いる半回転の中心を０°として表し、またＺ位置ρはＸ線源１０が半回転する間に寝台２が移動する移動範囲の中心位置を原点として、原点からの距離(mm)で表して、Ｘ線源１０の回転角度及び検出器のＺ位置の移動の変化に対して汎用化して示している。図９ではＸ線源１０が半回転する間に寝台２が40mm移動するように示している。図９の見方は、例えばＸ線源１０の回転角度ξが０°で、ファン内角度αが０°のときの近似パスは、Ｚ位置ρが０の投影データであり、これは通常、実在するであろう。勿論、このＺ位置ρの実在パスが実在しなければ、近似投影データは当該近似パスに最も近い２つのパス上の実在投影データから補間により作成される。

【００１８】（２）第２の近似パスの設定方法（図８（ｂ）参照）。

この方法は、近似パスの中心で仮想平面と交わるように近似パスを設定する。このような近似パスと仮想平面との交点は、Ｘ線源１０とＦＯＶ中心との距離を直径とするＸＹ面上の円筒を２軸方向に延長した円筒と、仮想平面である斜断面とが交差する僅かな楕円を描く。勿論、この近似パスの実在投影データが存在しなければ、上述したように補間により作成する。

【００１９】以上、近似パスの設定、換言すると近似投影データの作成例を２つ挙げたが、他にも変形例が考えられ、ここであげた２つの例に制約されるものではない。なお、補間に関して、回転角度とファン内角度の組み合わせ毎に、補間係数をあらかじめ求めておくことは、近似投影データの作成に当たって、補間係数の計算工程が不要とされ、計算量の軽減という観点から有効と

いえる。さらに、仮想平面の設定、近似パスの取り方についても、運用上は上記補間係数にすべて織り込むことができる。

【0020】次に具体例を挙げて説明する。ここでは、X線源10の回転半径を600mm、X線源10から2次元アレイ検出器11までの距離を1．1m、ファン角度を50度と仮定する。このときFOV（再構成領域）は600×sin(50°/2)で、約250mmになる。また、2次元アレイ検出器11は、Z方向（スライス方向）に9チャンネル、換言すると1次元アレイ検出器がZ方向に9列設けられたものであると仮定する。また、1次元アレイ検出器は、FOV中心においては1．4mm間隔に相当する列ピッチ（このとき列ピッチは2．57mmとなる）で配列されていると仮定する。また、X線源10が1回転する間に寝台2の移動量は15mmであると仮定する。このときのFOV内での近似パスと仮想平面のZ方向のずれは、計算によりプラス方向もマイナス方向も0．41mm程度と見積もれる。記憶部312からの近似投影データの取り出しは、図9にしたがって行われる。補間処理は、線形距離補間でもよいし、ｒｉｓｅｎ　ｃｏｓｉｎｅ関数を用いた補間のいずれでもよい。2次元アレイ検出器11上でのデータの必要範囲はプラスマイナス10．18mmと見積もれ、検出器11の存在範囲2．57mm×4＝10．28mmの中に入る。近似投影データ作成時に補間処理が入るため、FOV中心でのチャンネルの幅1．4mmに対して実行スライス厚はもっと厚く2mm程度になるであろう。このとき先のZ方向のエラー0．41mmは適当に小さいエラーであり、画質的に大きなアーチファクトを発生させるに至らないと理解される。

【0021】次に画像再構成について説明する。近似投影データから2次元のハーフ画像再構成を行えば画像が得られる。実際の処理としては、上述のようにして得られた近似投影データに対して従来通りの2次元ハーフ再構成を施すのみでよい。このとき、180度＋ファン角度分のデータを使うと、対向ビームが若干得られるが、この両者を加算平均してもよいし、一方を選択してもよい。もちろん、もう少し広い角度範囲でデータを取得し、対向ビームを「滑らかに重み付けて繋ぐ」ようにしてもよい。

【0022】ところで、再構成の座標系はZ方向に垂直なX、Y軸について再構成を行えばよく、これにより再構成面はわずかに傾きを持つが、これをZ方向から眺めた画像として得られる。仮想平面内の2次元座標を取り直すなどする必要性はない。もともとのデータはX，Y座標で収集されているということもあるし、また上述したように連続する再構成面が非平行であるので、かえってX、Y座標のままの方が3次元データとしての扱いが容易であると考えられる。

【0023】ボリュームデータの収集について以上の説明では、単一スライスの取得を中心に述べてきた。ボリュームデータを得るには、1枚の画像を再構成するのに必要な半回転範囲を、少しずらしてやればよい（図3（a）参照）。例えばX線源10の1回転の間に8枚の画像が欲しい場合には、360度／8＝45度のピッチで半回転範囲をずらして仮想平面を設定すればよい。

【0024】さて、X線源10の螺旋軌道に沿ってたとえば45度ピッチで順次画像を作成したとしても、得られる画像は非平行である。このため空間分解能がXY方向に変化するが、これは元々のX線源10の螺旋軌道の空間的な非対称性を反映したものと考えられその意味でごく自然なものであるといえる。

【0025】得られた一連の画像は非平行なので、互いに平行な断面や、曲断面変換像を含む断面変換像など、任意の2次元像を切り出す必要がある。各面は後述するP（ξ）の式によってその位置が与えられているのでこれに従って、算出すればよい。また、表面表示や投影像作成などの3次元画像処理を行う場合、互いに平行な断面を一旦作成してから、これを用いて処理を行うのが実際の適用上は最も便利であるが、精度を上げたい場合には得られた一連の非平行画像から直接処理を行うのがよい。

【0026】ヘリカルCT、及び2スライスのマルチスライスを行うデュアルスライスヘリカルCTに関して従来法と比較する。まず撮像のスピード・収集時間の効率について。先に示した例では、ヘリカルCTでは、例えば10cm分の厚みを持つ領域を2mmスライスデータとして欲しければ、1回転あたり寝台を2mm移動させ、50回転の撮影が必要であった。デュアルスライスのものでは、1回転あたり4mm移動させ25回転が必要である。本法を用いれば、上記の具体的計算例では、1回転あたり寝台を15mm移動させるので、7回転程度で済む事になる。次に再構成時のFOV内の投影ビームの存在位置のエラーについて考えよう。本法は近似手法であり、エラーは存在するが、上記具体的な計算例で示した例のように、適切な条件下では、十分な精度を持たせることができる。従来のヘリカルCTにおいても、隣接データとの補間処理は行っており、本法を用いても、従来法と同程度のエラーにて実行できるといえる。

【0027】図10はデータ収集から再構成までの一連の処理の流れを示すフローチャートであり、図11に或る斜断面を示す。1回転あたりの寝台移動量をh［mm］，仮想平面の傾きをκとするとき，ξｒａｄｉａｎ回転した位置，すなわち（ξh／2π）［mm］の位置を中心とした斜断面P（ξ）は

$$P(\xi)=\{(x,y,z)\ z=(\xi h/2\pi)+[(x,y)(-\sin\xi,\cos\xi)]\times\tan\kappa\}$$

で与えられる。ただし、「・」は内積を表す。

【0028】ここで、X線源10の回転角度β，ファン

内角度α、Z方向の位置ρとすると、この近似投影データをR（β，α，ρ）と表すものとする。実際には、投影データは離散的に得られるので、R（I（Δβ），m（Δα），n（Δρ））として表現される。なお、m＝－M／2～＋M／2、n＝－N／2～＋L／2である。

【0029】ヘリカルスキャンによりX線源10は数回転するので、βは広範囲となる。この範囲Iを、I＝LL1～LL2とする。また、ハーフ再構成に必要な範囲である実角度で－（π／2＋A）～（π／2＋A）に対応した範囲を－L／2～＋L／2と記述する。

【0030】さて、X線源10がξだけ回転した位置における斜断面の再構成について考えよう。この斜断面の再構成画像H（ξ）を再構成するために必要な全近似投影データの近似パスの検出器上のZ位置ρは、βとαの関数としてρ（β，α）として与えられる。

【0031】H（ξ）は、次のように得られる。

（STEP1）斜断面の近似投影データR（ξ，β，α）は、

R（ξ，β，α）＝R（ξ＋β，α，ρ（β，α））

で作成される。このとき、

ξ＋β＝（I（ξ））・（Δξ）

α＝（m（ξ））・（Δα）

（n－1）・（Δρ）≦ρ（β，α）＜n・（Δρ）とすると、実際には、

R（I（ξ）・（Δξ），m（ξ）・（Δα），α，（n－1）・（Δρ））

R（I（ξ）・（Δξ），m（ξ）・（Δα），α，n・（Δρ））

の2つの実在投影データから補間処理により近似投影データが作成される。

（STEP2）近似投影データR（ξ，β，α）を用いて所定のハーフ再構成アルゴリズムにより、ξだけ回転した方向に画像H（ξ）を再構成する。

【0032】なお、近似投影データRはヘリカルスキャンの実行中に順次必要な画像の再構成が終了次第、順次、消去してよいし、記憶部312の記憶容量が十分大きければ、ヘリカルスキャン終了後、再構成処理を実行するようにしてもよい。

【0033】本発明は上述した実施例に限定されず種々変形して実施可能である。以下に変形例を順次説明する。

（1）シフト機構の併用

本発明とシフト機構を併用することによって、分解能を向上させる事ができる。例えばX線源10の回転半径を上述の例の600mmを2／3の400mmになるように「シフト」させたとしよう。本法においては、これに連動してX線源10 1回転あたりの寝台の移動量も15mmから2／3の10mmに、スライス厚みも2／3とさせる。必ずしも連動させる必要はないが、スライス方向含めて全体的に分解能を向上させるのが最も効率がよい。

【0034】（2）部分角再構成法の利用

本発明の基本的アイデアは、X線源10の螺旋軌道の180°回転分程度は1つの平面に近似的に含まれることに着目し、このヘリカル斜断面に近いプロジェクションデータを抜き出し集めて、通常の2次元のハーフ再構成を行おうと言うものであった。螺旋軌道を一部分に限局すれば、その近似はよくなる。本法の変形例として、部分角再構成法を併用する。この方式を用いればX線源10の螺旋軌道と仮想平面の位置的な近似はきわめてよくなるので、仮想平面が更に傾斜角度を持っていても画像を得ることができる。従って「スライス方向のファン角度」も大きくすることが可能であり、撮影の効率は更に向上する。

【0035】（3）逆回転（寝台逆方向移動）への対応

実際の装置では、寝台の移動方向は、CT架台に挿入する方向、引き出す方向の双方向で使用する可能性がある。またX線源10の回転方向自体も逆回転含めて2通りが考えられる。この場合、被検体に対するX線源10の相対的な螺旋運動は鏡像対称であるので、上記のデータ処理（近似投影データの作成、逆投影演算の座標など）すべて鏡像対称とする。

【0036】

【発明の効果】本発明は、2次元アレイ検出器を用いてヘリカルスキャンにより投影データを収集するコンピュータ断層撮影装置において、実際に得られた2次元状の投影データから任意に定めた仮想平面の位置に近似するX線パスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成することを特徴とする。本発明によれば、実際に得られた2次元状の投影データから任意に定めた仮想平面の位置に近似するX線パスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成するので、2次元アレイ検出器を用いたヘリカルスキャン方式のCTで、簡易な処理でアーチファクトの少ない再構成画像を作成することができる。

【図面の簡単な説明】

【図1】本実施例に係るCTの構成図。

【図2】図1のデータ前処理装置のブロック図。

【図3】ヘリカルスキャンにおけるX線源の螺旋軌道を示す図。

【図4】90°ずつずらした斜断面の変化を示す図。

【図5】回転角度の変化に対する近似パスの検出面の交点群の変化を示す概念図。

【図6】X線源の螺旋軌道と仮想平面の装置を示す図。

【図7】ファン内角度0°の仮想パスと近似パスを示す図。

【図8】近似パスの設定方法の説明図。

【図9】1枚の断層像を再構成するのに必要な全ての近似パスのZ位置を示す図。

【図10】データ収集から再構成までの一連の処理の流

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れを示すフローチャート。
【図11】図10に対応する斜断面を示す図。
【符号の説明】
1…架台、 2…寝台、 3…コンソール、 4…高電圧発生装置、 5…高電圧制御装置、 10…X線源、 11…2次元アレ＊

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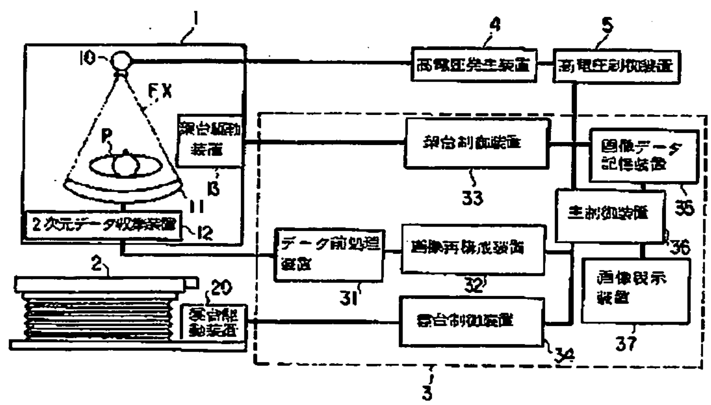
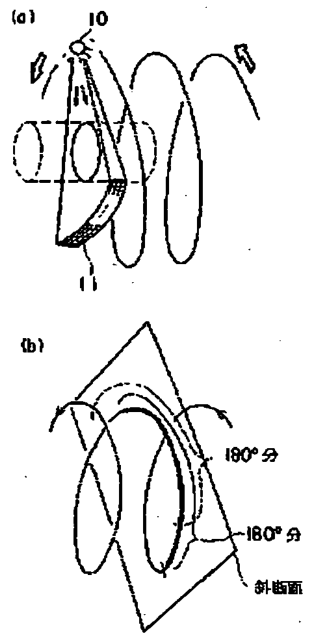
＊イ検出器、 3…架台駆動装置、 20…寝台駆動装置、 31…データ前処理装置、 32…画像再構成装置、 33…架台制御装置、 34…寝台制御装置、 35…画像データ記憶装置、 36…主制御装置、 37…画像表示装置。

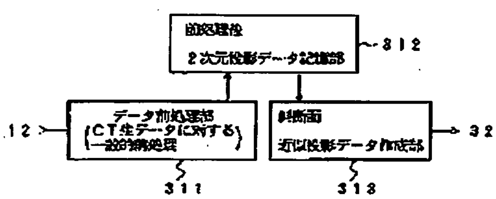
【図1】



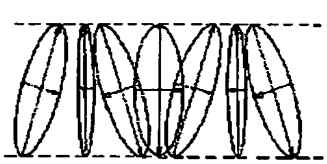
【図3】



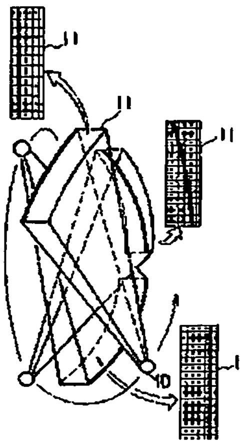
【図2】



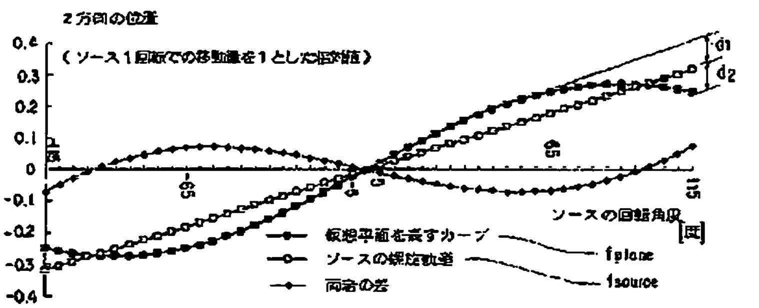
【図4】



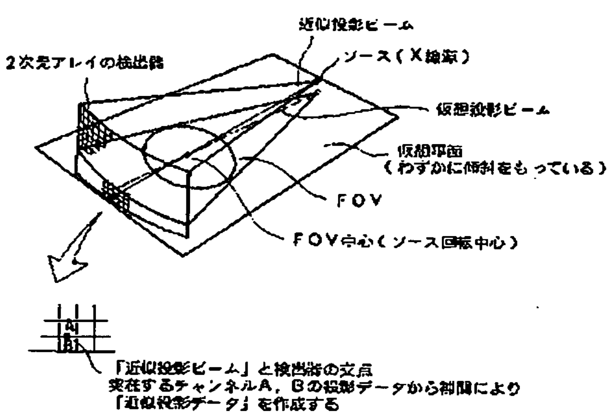
【図5】



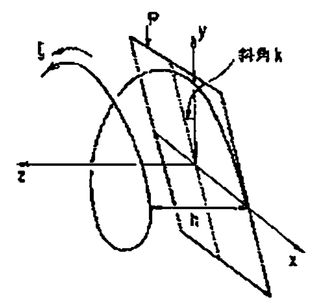
【図6】



【図7】



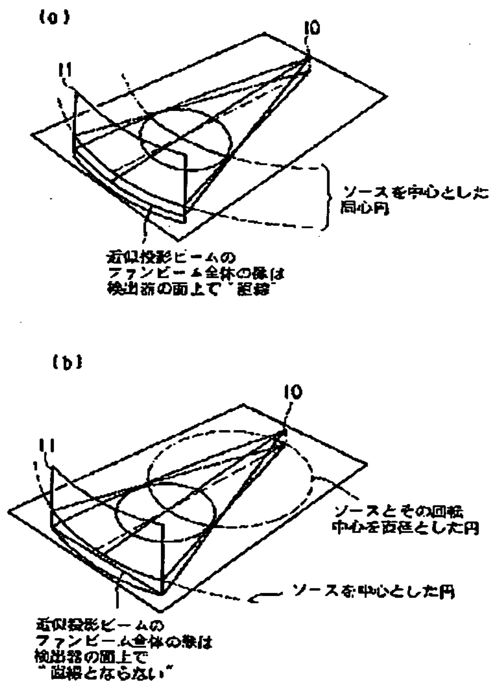
【図11】



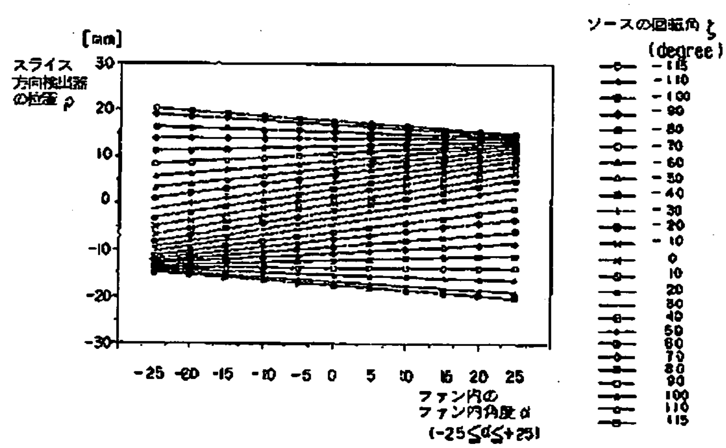
ζ 回転時の仮想平面(再構成面)P(ζ)

$P(\zeta)=\{(x,y,z)\mid z=(\zeta h/2\pi)+((x,y)\cdot(-\sin\zeta,\cos\zeta))\times\tan k\}$

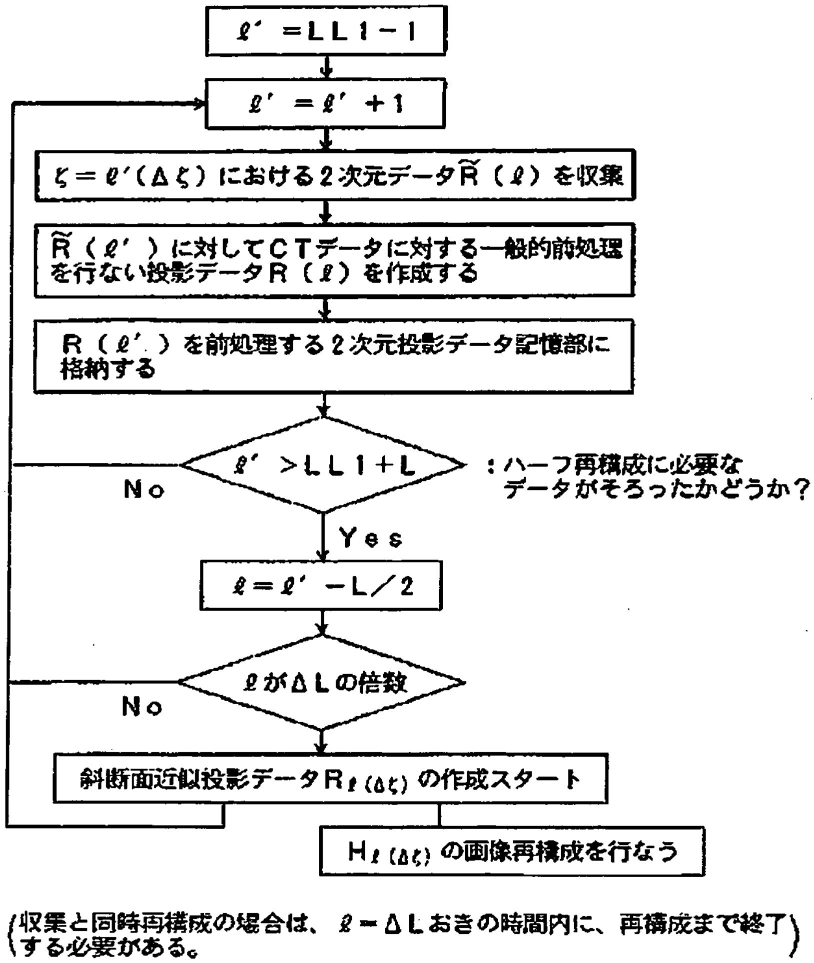
【図8】


(a)
10
11
ソースを中心とした
同心円
近似投影ビームの
ファンビーム全体の像は
検出器の面上で"直線"
(b)
10
11
ソースとその回転
中心を直径とした円
ソースを中心とした円
近似投影ビームの
ファンビーム全体の像は
検出器の面上で
"直線とならない"

【図9】


[mm]
スライス
方向検出器
の位置 ρ
30
20
10
0
-10
-20
-30
-25 -20 -15 -10 -5 0 5 10 15 20 25
ファン内の
ファン内角度 α
(-25≦α≦+25)
ソースの回転角 ζ
(degree)
-115
-110
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
115

【図10】


ℓ' ＝LL1－1
ℓ' ＝ℓ' ＋1
ξ＝ℓ'（Δξ）における2次元データR̃（ℓ）を収集
R̃（ℓ' ）に対してCTデータに対する一般的前処理を行ない投影データR（ℓ）を作成する
R（ℓ' ）を前処理する2次元投影データ記憶部に格納する
ℓ' ＞LL1＋L
：ハーフ再構成に必要なデータがそろったかどうか？
No
Yes
ℓ＝ℓ' －L／2
ℓがΔLの倍数
No
斜断面近似投影データ$R_{\ell(\Delta\xi)}$の作成スタート
$H_{\ell(\Delta\xi)}$の画像再構成を行なう
（収集と同時再構成の場合は、ℓ－ΔLおきの時間内に、再構成まで終了する必要がある。）

【公報種別】特許法第１７条の２の規定による補正の掲載
【部門区分】第１部門第２区分
【発行日】平成１４年４月９日（２００２．４．９）

【公開番号】特開平８－１８７２４０
【公開日】平成８年７月２３日（１９９６．７．２３）
【年通号数】公開特許公報８－１８７３
【出願番号】特願平７－２５１２
【国際特許分類第７版】
A61B 6/03 321
320
350
【ＦＩ】
A61B 6/03 321 N
320 Y
350 P

【手続補正書】
【提出日】平成１４年１月１０日（２００２．１．１０）
【手続補正１】
【補正対象書類名】明細書
【補正対象項目名】特許請求の範囲
【補正方法】変更
【補正内容】
【特許請求の範囲】
【請求項１】　２次元アレイ検出器を用いてヘリカルスキャンにより投影データを収集するコンピュータ断層撮影装置において，前記投影データから，設定された再構成面に近似するＸ線パスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成することを特徴とするコンピュータ断層撮影装置。
【請求項２】　前記近似投影データを同時に収集されたスライス方向に隣接する少なくとも２つの実際に得られた投影データの補間により求めることを特徴とする請求項１記載のコンピュータ断層撮影装置。
【請求項３】　前記再構成面は前記ヘリカルスキャンの中心軸に対して傾斜する斜断面として設定されることを特徴とする請求項１記載のコンピュータ断層撮影装置。
【請求項４】　前記再構成面を空間的に連続するように複数設定し、各再構成面について再構成像を再構成することによりボリュームデータを得ることを特徴とする請求項１記載のコンピュータ断層撮影装置。
【請求項５】　前記ヘリカルスキャンはＸ線源が被検体に対して相対的に螺旋軌道上を移動することにより実行され，前記再構成面を前記Ｘ線源が略１８０度回転する間の複数のＸ線パスにより描かれる湾曲面に近似する平面として設定されることを特徴とする請求項１記載のコンピュータ断層撮影装置。
【請求項６】　前記再構成面を、半螺旋の各回転角における前記Ｘ線源のＺ座標と，前記Ｘ線源の螺旋軌道により規定される円筒と前記再構成面とが交差する楕円のＺ座標との差の絶対値の最大値が、最小になるように設定することを特徴とする請求項５記載のコンピュータ断層撮影装置。
【請求項７】　前記再構成面を、半螺旋の各回転角における前記Ｘ線源のＺ座標と，前記Ｘ線源の螺旋軌道により規定される円筒と前記再構成面とが交差する楕円のＺ座標との差の二乗平均誤差が、最小になるように設定することを特徴とする請求項５記載のコンピュータ断層撮影装置。
【請求項８】　前記近似投影データは，前記Ｘ線源とＦＯＶ中心との距離を直径とする円筒と，前記再構成面の交差する楕円上を通過するＸ線パス上のデータであることを特徴とする請求項５記載のコンピュータ断層撮影装置。
【請求項９】　前記近似投影データは，前記Ｘ線源を中心にしてＦＯＶ中心を通る円筒と前記再構成面の交わる楕円を通過するＸ線パス上のデータであることを特徴とする請求項５記載のコンピュータ断層撮影装置。
【請求項１０】　前記２次元アレイ検出器のスライス方向の幅から換算したＦＯＶ中心でスライス方向の再構成厚みをｃとしたとき、前記Ｘ線源の１回転での被検体の相対的移動距離を略１．５ｃに設定することを特徴とする請求項５記載のコンピュータ断層撮影装置。
【請求項１１】　前記再構成は部分角再構成法を利用したものであることを特徴とする請求項１記載のコンピュータ断層撮影装置。
【請求項１２】　前記近似するＸ線パスは、Ｘ線源の回転角度に応じて決められることを特徴とする請求項１記載のコンピュータ断層撮影装置。
【請求項１３】　Ｘ線を曝射するＸ線源と、被検体を透

過したＸ線を検出する検出器が２次元状に配列された２次元検出器と、
前記２次元検出器の信号から前記被検体の投影データを収集するデータ収集装置と、
このデータ収集装置からの投影データを用いて、設定された再構成面の画像を再構成するのに必要な前記再構成面に近似するＸ線パスの近似投影データを作成するデータ作成部と、
前記近似投影データを用いて前記再構成面の画像を再構成する再構成装置と、を備えたことを特徴とするコンピュータ断層撮影装置。
【手続補正２】
【補正対象書類名】明細書
【補正対象項目名】０００７
【補正方法】変更
【補正内容】
【０００７】
【課題を解決するための手段】本発明は、２次元アレイ検出器を用いてヘリカルスキャンにより投影データを収集するコンピュータ断層撮影装置において、前記投影データから、設定された再構成面に近似するＸ線パスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成することを特徴とする。
【手続補正３】
【補正対象書類名】明細書
【補正対象項目名】０００８
【補正方法】変更
【補正内容】
【０００８】
【作用】本発明によれば、２次元アレイ検出器を用いてヘリカルスキャンにより得られた２次元状の投影データから、設定された再構成面に近似するＸ線パスの近似投影データを抽出し、この近似投影データを用いて再構成像を再構成するので、２次元アレイ検出器を用いたヘリカルスキャン方式のＣＴで、簡易な処理でアーチファクトの少ない再構成画像を作成することができる。
【手続補正４】
【補正対象書類名】明細書
【補正対象項目名】００１５
＊【補正方法】変更
【補正内容】
【００１５】例えば、ファン角度２Ａ＝５０°とすると、９０°＋Ａ＝１１５°となるが、このとき仮想平面の傾斜角（グラフ上はサインカーブｆplane の０度での傾きに相当）と、ヘリカルスキャン時のＸ線源１０の回転に対する寝台２の相対移動速度に応じたfsourceの傾きの比が1.095×(π/2)=1.720であるとき、両関数の差分ｄ１，ｄ２がほぼ一致する。すなわち両関数の差の絶対値の最大値（｜ｄ１－ｄ２｜）が、最小になるように、仮想平面を設定することにより、最もアーチファクトの少ない最適な仮想平面を特定することが可能である。このように両関数の差の絶対値の最大値に基づく方法の他に、両関数の差分の２乗平均が最小となるように仮想平面を設定する方法を採用してもよい。勿論、このような２つの方法に限定されるものではない。
【手続補正５】
【補正対象書類名】明細書
【補正対象項目名】００２４
【補正方法】変更
【補正内容】
【００２４】さて、Ｘ線源１０の螺旋軌道に沿ってたとえば４５度ピッチで順次画像を作成したとしても、得られる画像は非平行である。このためＺ方向の空間分解能が一定ではなく変化するが、これは元々のＸ線源１０の螺旋軌道の空間的な非対称性を反映したものと考えられその意味でごく自然なものであるといえる。
【手続補正６】
【補正対象書類名】明細書
【補正対象項目名】００２７
【補正方法】変更
【補正内容】
【００２７】図１０はデータ収集から再構成までの一連の処理の流れを示すフローチャートであり、図１１に或る斜断面を示す。１回転あたりの寝台移動量をｈ［ｍｍ］，仮想平面の傾きをκとするとき，ξｒａｄｉａｎ回転した位置，すなわち（ξｈ／２π）［ｍｍ］の位置を中心とした斜断面Ｐ（ξ）は＊

$$P(\xi)=\{(x,y,z)\ z=(\xi h/2\pi)+[(x,y)\cdot(-\sin\xi,\cos\xi)]\times\tan\kappa\}$$

で与えられる。ただし、「・」は内積を表す。
【手続補正７】
【補正対象書類名】明細書
【補正対象項目名】００３６
【補正方法】変更
【補正内容】
【００３６】
【発明の効果】本発明によれば、簡易な処理でアーチファクトの少ない再構成画像を作成することができる。

CLAIMS

[Claim(s)]
[Claim 1] The computerized-tomography scanning equipment characterized by extracting the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration from the actually acquired two-dimensional projection data in the computerized-tomography scanning equipment which collects projection data by helical scan using a two-dimensional-array detector, and reconfigurating a reconstruction image using this approximation projection data.
[Claim 2] The computerized-tomography scanning equipment according to claim 1 characterized by asking for said approximation projection data with interpolation of at least two actually obtained projection data which adjoins in the slice direction collected by coincidence.
[Claim 3] Said virtual flat surface is a computerized-tomography scanning equipment according to claim 1 characterized by being set up as a slanting cross section which inclines to the medial axis of said helical scan.
[Claim 4] The computerized-tomography scanning equipment according to claim 1 which carries out the multi-statement of said virtual flat surface so that it may continue spatially, and is characterized by obtaining volume data by reconfigurating a reconstruction image about each virtual flat surface.
[Claim 5] Said helical scan is a computerized-tomography scanning equipment according to claim 1 characterized by being set up as a flat surface approximated to the curve side drawn with two or more X-ray pass while it performs when X line source moves relatively to analyte in a spiral orbit top, and said X line source rotates said virtual flat surface 180 abbreviation.
[Claim 6] The computerized-tomography scanning equipment according to claim 5 characterized by the maximum of the absolute value of a difference with the Z coordinate of the ellipse which the Z coordinate of said X line source in each angle of rotation of a half-spiral, and the cylinder specified by the spiral orbit of said X line source and said virtual flat surface intersect setting up said virtual flat surface so that it may become min.
[Claim 7] The computerized-tomography scanning equipment according to claim 5 characterized by setting up said virtual flat surface so that the mean square error of a difference with the Z coordinate of the ellipse which the Z coordinate of said X line source in each angle of rotation of a half-spiral, and the cylinder specified by the spiral orbit of said X line source and said virtual flat surface intersect may become min.
[Claim 8] Said approximation projection data is a computerized-tomography scanning equipment according to claim 5 characterized by being data on the X-ray pass which passes through the cylinder [which makes a diameter distance of said X line source and FOV core], and ellipse top which said virtual flat surface intersects.
[Claim 9] Said approximation projection data is a computerized-tomography scanning equipment according to claim 5 characterized by being data on the X-ray pass which passes the ellipse at which said virtual flat surface crosses the cylinder which passes along a FOV core focusing on said X line source.
[Claim 10] The computerized-tomography scanning equipment according to claim 5 characterized by setting the relative movement distance of the analyte in one rotation of said X line source as abbreviation 1.5c when reconstruction thickness of the slice direction is set to c focusing on FOV converted from the width of face of the slice direction of said two-dimensional-array detector.

[Claim 11] Said reconstruction is a computerized-tomography scanning equipment according to claim 1 characterized by using a partial angle reconstruction method.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the computerized-tomography scanning equipment (it abbreviates to "CT" below) of a helical scan.
[0002]
[Description of the Prior Art] Generally CT with the 1-dimensional detector which arranged the detector which detects the X-ray which penetrated current and analyte to one dimension has spread. And in recent years, the so-called helical scan which X line source draws a spiral orbit and moves in the moving coordinate which moves with a berth by moving a berth, carrying out continuation rotation of X line source (source) and the detector is beginning to spread quickly. Furthermore, the formation of many trains of a 1-dimensional detector and cone beam-ization of an exposure X-ray grope for the implementability of three-dimension-izing of data.
[0003] In the helical scan by the 1-dimensional detector, in order that X line source may move a spiral orbit, it is required to carry out interpolation creation of the great portion of projection data on a reconstruction cross section in approximation by linear interpolation processing etc. This created data is hereafter called approximation projection data. Since the data for one rotation were substantially needed, when reconstruction wanted the field which has the thickness for 10cm, for example as 2mm slice data, it needed the scan of 50 rotations.
[0004] As for 2 successive installation beam ******** dual slice helical method, a data collection rate becomes twice the above-mentioned method theoretically about a 1-dimensional detector. Although it is possible to develop this and to form a 1-dimensional detector into many trains, it becomes impossible for the X-ray pass between trains to regard it as parallel. It will consider that this is parallel temporarily and will become the image which does not bear practical use with much artifact in having reconfigurated the image as a multi-slice for every train simply. The current proposal of the technique of conquering these problems was not made, therefore twice [at most] as many improvement in the speed as this has concluded that it is a limit by this method.
[0005] By the cone beam scanning method, when analyte is completely contained in a cone beam, perfect reconstruction is theoretically possible, but when analyte is not completely contained in a cone beam, the solution method of suitable reconstruction is not proposed.
[0006]
[Problem(s) to be Solved by the Invention] As mentioned above, by CT of the helical scan using a two-dimensional-array detector, it simplifies and few reconstruction approaches of the artifact do not exist. The purpose of this invention is CT of the helical scan which used the two-dimensional-array detector, and is offering CT which can create few reconstruction images of the artifact by simple processing.
[0007]
[Means for Solving the Problem] In the computerized-tomography scanning equipment which collects projection data by helical scan using a two-dimensional-array detector, this invention extracts the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration from the actually acquired two-dimensional projection data, and is characterized by reconfigurating a reconstruction image using this approximation projection data.
[0008]

[Function] Since according to this invention the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration is extracted from the actually acquired two-dimensional projection data and a reconstruction image is reconfigurated using this approximation projection data, few reconstruction images of the artifact can be created by simple processing by CT of the helical scan using a two-dimensional-array detector.
[0009]
[Example] Hereafter, one example of the computerized-tomography scanning equipment (it abbreviates to "CT" hereafter) by this invention is explained. Drawing 1 is the block diagram of CT concerning this example, and drawing 2 is the block diagram of the data pre-treatment equipment of drawing 1 . CT consists of a stand 1, a berth 2, and a console 3 greatly. Opening of a cylindrical shape can open in the core of a stand 1, and at the time of a scan, where Analyte P is laid in a berth 2, it is inserted in it. In addition, the horizontal axis which intersects perpendicularly a horizontal axis parallel to the direction of a body axis of Analyte P with the Z-axis, and intersects a vertical axis perpendicularly with a Y-axis and the Z-axis is defined as the X-axis. A berth 2 is constituted movable, driving to the berth driving gear 20 and laying Analyte P. The X line source 10 ****** flabellate form X-ray beam FX in response to the high voltage from a high-voltage transformer assembly 4. Whenever [angle-of-divergence / of this flabellate form X-ray beam FX] is called fan include angle, and is made into **A degrees and sum total 2A" on both sides of a medial axis at right and left. As a typical example, the fan include angle is set as 50 degrees. The two-dimensional-array detector 12 comes to arrange the detector which detects the X-ray which penetrated Analyte P as an electrical signal in the shape of two-dimensional. with the condition that the X line source 10 and the two-dimensional-array detector 12 countered according to the rolling mechanism and slip ring device which are not illustrated -- the perimeter of Analyte P -- continuation -- it is supported pivotable. This rotation is driven with the stand driving gear 13. With the two-dimensional data collector 12, it integrates with the output of the two-dimensional-array detector 12 in time, and it is digitized and are collected as projection data. The stand driving gear 13 is controlled by the stand control unit 33, and the berth driving gear 20 is controlled for a high-voltage transformer assembly 4 by the high-voltage control unit 5 at the berth control unit 34, respectively.
[0010] It is sent to the data pre-treatment equipment 31, and the projection data from the two-dimensional data collector 12 is at the data pretreatment section 311 first. After general pretreatment of Log conversion (logarithmic transformation) etc. is performed, the after [pretreatment] two-dimensional projection data storage section 312 memorizes. The slanting cross-section approximation projection data origination section 313 creates approximation projection data required to reconfigurate the image about a slanting cross section using the projection data after pretreatment. The image re-component 32 reconfigurates an image (slanting cross-section image) from the approximation projection data created in the slanting cross-section approximation projection data origination section 313. The so-called half reconstruction approach which can reconfigurate an image from the projection data for 180 degrees is adopted as this reconstruction processing. This tomogram data is sent and displayed on an image display device 37 through the main control section 36, and is sent to the image data storage 35, and is memorized. The main control section 36 controls the high-voltage control unit 5, the stand control unit 33, and the berth control unit 34, and performs helical scan.
[0011] Next, an operation of this example is explained. In addition, the moving coordinate of explanation which moves with Analyte P is specified for convenience. In this moving coordinate, by helical scan, the X line source 10 will move a spiral orbit, as shown in drawing 3 (a). In an actual motion, while the X line source 10 and the two-dimensional-array detector 11 carry out continuation rotation, Analyte P moves to an one direction on a berth 2. Here, the jargon treated by the following explanation is defined.
- Actual existence projection data; projection data on the X-ray pass (it is called a virtual path) which is needed in order to reconfigurate the image of the projection data and the virtual projection data; reconstruction side of the actual existence actually collected with each detector of the two-dimensional-array detector 11 (here, it defines as a slanting cross section) and which is included ideal, i.e., the reconstruction side concerned. In helical scan, such virtual projection data does not exist really except for some exceptions.

- Approximation projection data; projection data on the X-ray pass in X-ray beam FX most approximated to a virtual path (it is called approximation pass). In addition, this approximation projection data may not exist really by existing really as actual existence projection data. When it does not exist really, it creates with interpolation (distance interpolation) from the actual existence projection data near approximation pass. Approximation projection data is created by every [of the X-ray from the X line source 10 / one / every] radiation direction (a definition is given as whenever [fan interior angle]) about angle of rotation of each of the X line source 10.
[0012] In addition, two or more X-ray pass required for reconstruction cannot define the flat surface of one sheet in helical scan. One of the descriptions of this example sets up the slanting cross section (reconstruction side) which inclines to the Z-axis to the X-ray pass group for half-rotation of the X line source 10, and it is to reconfigurate an image using the projection data for this half-rotation (refer to drawing 3 (b)). Thereby, there are few gaps with the curve side and reconstruction side which are drawn by the X-ray pass group for half-rotation, and they can reconfigurate an image with little artifact. Furthermore, the description of this example is setting up the slanting cross section where the artifact's makes min the min of gaps, i.e., the above-mentioned amount, to the X-ray pass group for half-rotation, and setting approximation pass. Approximation pass is specified by Z location angle of rotation of the X line source 10, and whenever [fan interior angle].
[0013] The volume data of a three dimension are obtained by repeating reconstruction processing, shifting a slanting cross section little by little in accordance with the spiral orbit of the X line source 10. Spatial resolving power changes according to the migration pitch of this slanting cross section. For example, change of the slanting cross section which it shifted 90 degrees at a time to drawing 4 is shown. According to this approach, a minute (it changes according to a migration pitch) of an image can be reconfigurated, for example by one rotation several times of the helical CT of the single slice put in practical use until now or a dual slice.
[0014] It explains below at a detail.
- Although the slanting cross section mentioned above what is specified in approximation by the X-ray pass group which moves while 180 degrees of X line sources 10 rotate about a setup of the virtual flat surface (slanting cross section) which should be reconfigurated, it is necessary to specify the virtual flat surface used as the min of the above-mentioned amount of gaps approximated most. The angle of rotation of the X line source 10 and the axis of ordinate are expressed [the spiral orbit of the X line source 10 (source)] for the axis of abscissa as a Z coordinate to drawing 6 . The spiral orbit of the X line source 10 is shown on this graph by the primary straight line fsource passing through a zero. On the other hand, a virtual flat surface is the sign curve fplane on this graph. It is shown by carrying out. Here, 180 degree+ fan include-angle 2A, a part for i.e., ** (90degree+A), is given as a view required for half reconstruction focusing on 0 degree. fsource and fplane It will be easily understood that the amount of gaps of a virtual flat surface and the curve side drawn by the X-ray pass group for half-rotation of the spiral orbit of the X line source 10 is small, so that the integral of a difference is small.
[0015] For example, if fan include-angle 2A=50 degree, it will become 90 degree+A=115 degree, but when the ratio of the tilt angle (a graph top is equivalent to the inclination in 0 times of the sign curve fplane) of a virtual flat surface and the inclination of fsource according to the relative-displacement rate of the berth 2 to rotation of the X line source 10 at the time of helical scan is 1.095 at this time, the difference d1 and d2 of both functions is mostly in agreement. That is, the maximum (|d1-d2|) of the absolute value of the difference of both functions is able to specify few optimal virtual flat surfaces of the artifact most by setting up a virtual flat surface so that it may become min. Thus, the approach of setting up a virtual flat surface so that the root mean square of the difference of both functions other than the approach based on the maximum of the absolute value of the difference of both functions may serve as min may be adopted. Of course, it is not limited to such two approaches.
[0016] - The virtual path contained in a virtual flat surface is rare, therefore virtual projection data hardly exists as actual existence projection data so that I may be understood with reference to drawing 6 about a setup of approximation pass. Therefore, the approximation pass nearest to the virtual path in a flabellate form X-ray beam with fixed thickness is set. Here, when 0 degree is considered whenever [fan interior angle], the pass on the virtual flat surface which passes along the

core (it is the same as the center of rotation of the X line source 10) of FOV (Field of View) like drawing 7 is a virtual path. On the other hand, approximation pass is given as pass which passes along a FOV core from the X line source 10. Let the actual existence projection data which passes along this approximation pass be approximation projection data about 0 degree whenever [fan interior angle]. If actual existence projection data existence is not recognized through this approximation pass, approximation projection data is created with interpolation from two actual existence projection data of the channels A and B nearest to the intersection of the approximation pass and a detector side concerned. A thick wire shows notionally change of the intersection group of the detection side of approximation pass to change of angle of rotation to drawing 5 . Two kinds of examples are offered about the setting approach of approximation pass.

[0017] (1) The setting approach of the 1st approximation pass (refer to drawing 8 (a))

By this approach, when it sees about an certain angle of rotation of the X line source 10, the intersection to the detection side top of approximation pass will be drawn "in a straight line" with change which is whenever [fan interior angle]. As mentioned above, 0-degree approximation pass is set whenever [fan interior angle] so that a virtual flat surface may be intersected focusing on FOV. An approximation pass group is set up so that the slightly flat ellipse of the virtual flat surface where the intersection of the approximation pass of whenever [other fan interior angle] and a virtual flat surface made the radius from the X line source 10 to the FOV core the core [the X line source 10] may be drawn. It is mentioned that whenever [of actual count / complicated] is small as for the advantage of this approach. All approximation pass required to reconfigurate the tomogram for one sheet by this approach to drawing 9 is shown. In addition, the angle of rotation zeta of the X line source 10 expresses with drawing 9 the core of half-rotation that not an include angle but the X line source 10 uses for reconstruction absolutely, as 0 degree, and the Z location rho makes a zero the center position of the successive range where a berth 2 moves while the X line source 10 half-rotates. It expresses with the distance (mm) from a zero, and is used widely and shown to change of migration of angle of rotation of the X line source 10, and Z location of a detector. By drawing 9 , while the X line source 10 half-rotates, it is indicated that a berth 2 moves 40mm. The angle of rotation zeta of the X line source 10 of the view of drawing 9 is 0 degree, the Z location rho of approximation pass in case alpha is 0 degree whenever [fan interior angle] is projection data of 0, and, probably, this usually exists really. Of course, if the actual existence pass of this Z location rho does not exist really, approximation projection data is created by interpolation from the actual existence projection data on two pass nearest to the approximation pass concerned.

[0018] (2) The setting approach of the 2nd approximation pass (refer to drawing 8 (b)).

This approach sets approximation pass so that a virtual flat surface may be crossed at the core of approximation pass. The intersection of such an approximation pass and a virtual flat surface draws few ellipses which the cylinder which extended the periphery on XY side which makes a diameter the X line source 10 and distance based on FOV(s) to Z shaft orientations, and the slanting cross section which is a virtual flat surface intersect. Of course, if the actual existence projection data of this approximation pass does not exist, as mentioned above, it creates with interpolation.

[0019] As mentioned above, it is not restrained by a setup of approximation pass, and two examples which could otherwise consider the modification and were raised here although two examples of creation of approximation projection data were given when put in another way. In addition, about interpolation, for every combination of angle of rotation and whenever [fan interior angle], it is made unnecessary [the count process of a interpolation multiplier] in creation of approximation projection data to ask for a interpolation multiplier beforehand, and it can be said from a viewpoint of mitigation of computational complexity that it is effective. Furthermore, a setup of a virtual flat surface and approximation pass can take, and an employment top can be altogether woven into the above-mentioned interpolation multiplier also about the direction.

[0020] Next, an example is given and explained. Here, the distance from 600mm and the X line source 10 to the two-dimensional-array detector 11 is assumed to be 1.1m, and a fan include angle is assumed to be 50 degrees for the radius of gyration of the X line source 10. At this time, FOV (reconstruction field) is 600xsin (50 degrees/2). It is set to about 250mm. moreover, if the two-dimensional-array detector 11 is put in another way nine channels to a Z direction (the slice direction), a one dimensional array detector will assume that it is 9 successive-installation ********

to a Z direction. Moreover, it is assumed that the one dimensional array detector is arranged with the row pitch (a row pitch is set to 2.57mm at this time) which is equivalent to 1.4mm spacing at a FOV core. Moreover, while the X line source 10 rotates one time, it is assumed that the movement magnitude of a berth 2 is 15mm. A gap of approximation pass within FOV at this time and the Z direction of a virtual flat surface can also estimate the plus direction and minus direction at about 0.41mm by count. Ejection of the approximation projection data from the storage section 312 is performed according to drawing 9 . Linearity distance interpolation may be used for interpolation processing, and it is risen. Any of the interpolation using a cosine function are sufficient. The need range of the data on the two-dimensional-array detector 11 can be estimated at double sign 10.18mm, and enters into existence range 2.57mmx4=10.28mm of a detector 11. Activation slice thickness will be more thickly set to about 2mm to width of face of 1.4mm of the channel based on FOV(s), in order that interpolation processing may enter at the time of approximation projection data origination. At this time, error 0.41mm of a previous Z direction is a small error suitably, and is understood by not coming to generate the big artifact in image quality.
[0021] Next, image reconstruction is explained. An image will be obtained if two-dimensional half image reconstruction is performed from approximation projection data. As actual processing, it is good only by performing two-dimensional half reconstruction as usual to the approximation projection data obtained as mentioned above. Although an opposed beam will be obtained a little if the data for a 180 degree + fan include angle are used at this time, averaging of these both may be carried out and one side may be chosen. Of course, data are acquired in a little larger include-angle range, and it is good as for a method of "being weighting ****** smoothly" in an opposed beam.
[0022] By the way, that the system of coordinates of reconstruction should just reconfigurate about X perpendicular to a Z direction, and a Y-axis, although a reconstruction side has an inclination slightly by this, it is obtained as an image which looked at this from the Z direction. There is no need of restarting the two-dimensional coordinate within a virtual flat surface. Since the reconstruction side which continues as it may say that data from the first are collected by X and Y coordinate and being mentioned above is not parallel, it is thought that the direction with X and Y coordinate is easy to treat as three-dimension data on the contrary.
[0023] The above explanation has described collection of volume data focusing on acquisition of a single slice. What is necessary is just to shift a little half-rotation range required to reconfigurate the image of one sheet, in order to obtain volume data (refer to drawing 3 (a)). For example, what is necessary is to shift the half-rotation range in the pitch of 360 degrees / 8= 45 degrees, and just to set up a virtual flat surface between 1 rotations of the X line source 10, in wanting the image of eight sheets.
[0024] Now, the image obtained is not parallel even if it creates an image one by one in a pitch 45 degrees in accordance with the spiral orbit of the X line source 10. For this reason, although spatial resolving power changes in the XY direction, this is considered reflecting the spatial asymmetry of the spiral orbit of the X line source 10 from the first, and it can be said in that semantics that it is very natural.
[0025] Since a series of obtained images are un-parallel, it is necessary to start two-dimensional images of arbitration, such as an parallel cross section and a cross-section conversion image containing a music cross-section conversion image, mutually. What is necessary is just to compute each field according to this, since the location is given by the formula of P (zeta) mentioned later. Moreover, although the employment top with actual processing using this is the most convenient once it creates an parallel cross section mutually when performing three-dimension image processings, such as a surface display and projection image creation, it is good to raise precision to perform direct processing from a series of obtained un-parallel images.
[0026] It compares with a conventional method about helical CT and the dual slice helical CT which performs the multi-slice of 2 slices. About the effectiveness of the speed and the acquisition time of first an image pick-up When he wanted the field which has the thickness for 10cm in helical CT in the example shown previously, for example as 2mm slice data, the berth was moved 2mm per rotation and 50 rotations needed to take a photograph. It is made to move 4mm per rotation, and 25 rotations are required of the thing of a dual slice. If this method is used, since a berth is moved 15mm per rotation, it will end with 7 rotation extent in the above-mentioned example of concrete

count. Next, I will consider the error of a projection beam's in FOV at time of reconstruction existence location. although this method is the approximation technique and an error exists -- the above -- like the example shown in the concrete example of count, sufficient precision can be given under suitable conditions. Also in the conventional helical CT, interpolation processing with contiguous data is performed, and even if it uses this method, it can be said that it can perform in an error comparable as a conventional method.

[0027] Drawing 10 is a flow chart which shows the flow of a series of processings from data collection to reconstruction, and shows a certain slanting cross section to drawing 11 . When setting the inclination of h [mm] and a virtual flat surface to kappa for the berth movement magnitude per rotation, The slanting cross section P (zeta) centering on the location which carried out zetaradian rotation, i.e., (zetah/2pi), the location of [mm], is P(zeta) = {(x y, z) z= (zetah / 2pi)+[(x y)](-sin zeta, coszeta) xtan kappa}.

It is come out and given. However, "-" expresses an inner product.

[0028] Here, if it is the angle of rotation beta of the X line source 10, whenever [fan interior angle / alpha], and the location rho of a Z direction, this approximation projection data shall be expressed as R (beta, alpha, rho). In fact, since projection data is obtained discretely, it is expressed as R (l (**beta), m (**alpha), n (**rho)). In addition, it is m=-M / 2 - +M/2, and n=-N / 2 - +L/2.

[0029] Since the X line source 10 carries out number rotation by helical scan, beta becomes wide range. This range I is set to I=LL1 - LL2. Moreover, range corresponding to -(pi/2+A) - (pi/2+A) at the real include angle which is the range required for half reconstruction - It is described as L / 2 - +L/2.

[0030] Now, the X line source 10 will consider reconstruction of the slanting cross section in the location which only zeta rotated. The Z location rho on the detector of the approximation pass of all approximation projection data required in order to reconfigurate the reconstruction image H of this slanting cross section (zeta) is given as rho (beta, alpha) as a function of beta and alpha.

[0031] H (zeta) is obtained as follows.

(STEP1) Approximation projection data R (zeta, beta, alpha) of a slanting cross section is R(zeta, beta, alpha) =R (zeta+beta, alpha, rho (beta, alpha)).

It is come out and created. At this time, it is zeta+beta=(I (zeta)) - (**zeta).

alpha=(m (zeta)) - (**alpha)

(n-1) When -(**rho) <=rho(beta, alpha) <n- (**rho), it is R (I(zeta) - (**zeta), m(zeta) - (**alpha), alpha, - (n-1) (**rho)) in fact.

R (I(zeta) - (**zeta), m(zeta) - (**alpha), alpha, n- (**rho))

Approximation projection data is created by interpolation processing from the actual existence projection data of two **.

(STEP2) Image H (zeta) is reconfigurated with a predetermined half reconstruction algorithm in the direction which only zeta rotated using approximation projection data R (zeta, beta, alpha).

[0032] In addition, as soon as reconstruction of an image required one by one during activation of helical scan is completed, one by one, as long as the storage capacity of the storage section 312 is large enough, it may be made to eliminate approximation projection data R, and to perform reconstruction processing after helical scan termination.

[0033] This invention cannot be limited to the example mentioned above, but can deform variously, and can be carried out. Sequential explanation of the modification is given below.

(1) Resolution can be raised by using together concomitant use this invention of a shift device, and a shift device. For example, the juniper the radius of gyration of the X line source 10 "was shifted" so that 600mm of an above-mentioned example might be set to two thirds of 400mm. This is interlocked with and slice thickness also makes 10mm of 2/3 also set movement magnitude of the berth per X line source 101 rotation to two thirds from 15mm in this method. Although it is not necessary to make it not necessarily interlock, it is most efficient for the whole slice direction ****** target to raise resolution.

[0034] (2) It was what is referred to as that 180-degree rotation part extent of the spiral orbit of the X line source 10 will extract and bring together the projection data near this helical slanting cross section in one flat surface paying attention to being contained in approximation, and the fundamental idea of use this invention of a partial angle reconstruction method will perform the usual two-

dimensional half reconstruction. If the ** office of the spiral orbit is carried out to a part, the part approximation will become good. A partial angle reconstruction method is used together as a modification of this method. Since location-approximation of the spiral orbit of the X line source 10 and a virtual flat surface will become very good if this method is used, an image can be obtained even if the virtual flat surface has whenever [tilt-angle] further. Therefore, "the fan include angle of the slice direction" can be enlarged and the effectiveness of photography improves further.
[0035] (3) the correspondence to inverse rotation (berth hard flow migration) -- in actual equipment, the migration direction of a berth may be used in both directions of the direction inserted in CT stand, and the direction to pull out. Moreover, the hand of cut of the X line source 10 itself can consider two kinds of inverse rotation ******. in this case -- since the relative screw motion of the X line source 10 over analyte is symmetrical with a mirror image -- the above-mentioned data processing (creation of approximation projection data, coordinate of a back projection operation, etc.) -- all are considered as the mirror image symmetry.
[0036]
[Effect of the Invention] In the computerized-tomography scanning equipment which collects projection data by helical scan using a two-dimensional-array detector, this invention extracts the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration from the actually acquired two-dimensional projection data, and is characterized by reconfigurating a reconstruction image using this approximation projection data. Since according to this invention the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration is extracted from the actually acquired two-dimensional projection data and a reconstruction image is reconfigurated using this approximation projection data, few reconstruction images of the artifact can be created by simple processing by CT of the helical scan using a two-dimensional-array detector.

[Translation done.]

TECHNICAL FIELD

[Industrial Application] This invention relates to the computerized-tomography scanning equipment (it abbreviates to "CT" below) of a helical scan.

[Translation done.]

* NOTICES *

PRIOR ART

[Description of the Prior Art] Generally CT with the 1-dimensional detector which arranged the detector which detects the X-ray which penetrated current and analyte to one dimension has spread. And in recent years, the so-called helical scan which X line source draws a spiral orbit and moves in the moving coordinate which moves with a berth by moving a berth, carrying out continuation rotation of X line source (source) and the detector is beginning to spread quickly. Furthermore, the formation of many trains of a 1-dimensional detector and cone beam-ization of an exposure X-ray grope for the implementability of three-dimension-izing of data.
[0003] In the helical scan by the 1-dimensional detector, in order that X line source may move a spiral orbit, it is required to carry out interpolation creation of the great portion of projection data on a reconstruction cross section in approximation by linear interpolation processing etc. This created data is hereafter called approximation projection data. Since the data for one rotation were substantially needed, when reconstruction wanted the field which has the thickness for 10cm, for example as 2mm slice data, it needed the scan of 50 rotations.
[0004] As for 2 successive installation beam ******** dual slice helical method, a data collection rate becomes twice the above-mentioned method theoretically about a 1-dimensional detector. Although it is possible to develop this and to form a 1-dimensional detector into many trains, it becomes impossible for the X-ray pass between trains to regard it as parallel. It will consider that this is parallel temporarily and will become the image which does not bear practical use with much artifact in having reconfigurated the image as a multi-slice for every train simply. The current proposal of the technique of conquering these problems was not made, therefore twice [at most] as many improvement in the speed as this has concluded that it is a limit by this method.
[0005] By the cone beam scanning method, when analyte is completely contained in a cone beam, perfect reconstruction is theoretically possible, but when analyte is not completely contained in a cone beam, the solution method of suitable reconstruction is not proposed.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] In the computerized-tomography scanning equipment which collects projection data by helical scan using a two-dimensional-array detector, this invention extracts the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration from the actually acquired two-dimensional projection data, and is characterized by reconfigurating a reconstruction image using this approximation projection data. Since according to this invention the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration is extracted from the actually acquired two-dimensional projection data and a reconstruction image is reconfigurated using this approximation projection data, few reconstruction images of the artifact can be created by simple processing by CT of the helical scan using a two-dimensional-array detector.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] As mentioned above, by CT of the helical scan using a two-dimensional-array detector, it simplifies and few reconstruction approaches of the artifact do not exist. The purpose of this invention is CT of the helical scan which used the two-dimensional-array detector, and is offering CT which can create few reconstruction images of the artifact by simple processing.

[Translation done.]

MEANS

[Means for Solving the Problem] In the computerized-tomography scanning equipment which collects projection data by helical scan using a two-dimensional-array detector, this invention extracts the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration from the actually acquired two-dimensional projection data, and is characterized by reconfigurating a reconstruction image using this approximation projection data.

[Translation done.]

OPERATION

[Function] Since according to this invention the approximation projection data of the X-ray pass approximated to the location of the virtual flat surface set to arbitration is extracted from the actually acquired two-dimensional projection data and a reconstruction image is reconfigurated using this approximation projection data, few reconstruction images of the artifact can be created by simple processing by CT of the helical scan using a two-dimensional-array detector.

[Translation done.]

EXAMPLE

[Example] Hereafter, one example of the computerized-tomography scanning equipment (it abbreviates to "CT" hereafter) by this invention is explained. Drawing 1 is the block diagram of CT concerning this example, and drawing 2 is the block diagram of the data pre-treatment equipment of drawing 1 . CT consists of a stand 1, a berth 2, and a console 3 greatly. Opening of a cylindrical shape can open in the core of a stand 1, and at the time of a scan, where Analyte P is laid in a berth 2, it is inserted in it. In addition, the horizontal axis which intersects perpendicularly a horizontal axis parallel to the direction of a body axis of Analyte P with the Z-axis, and intersects a vertical axis perpendicularly with a Y-axis and the Z-axis is defined as the X-axis. A berth 2 is constituted movable, driving to the berth driving gear 20 and laying Analyte P. The X line source 10 ****** flabellate form X-ray beam FX in response to the high voltage from a high-voltage transformer assembly 4. Whenever [angle-of-divergence / of this flabellate form X-ray beam FX] is called fan include angle, and is made into **A degrees and sum total 2A" on both sides of a medial axis at right and left. As a typical example, the fan include angle is set as 50 degrees. The two-dimensional-array detector 12 comes to arrange the detector which detects the X-ray which penetrated Analyte P as an electrical signal in the shape of two-dimensional. with the condition that the X line source 10 and the two-dimensional-array detector 12 countered according to the rolling mechanism and slip ring device which are not illustrated -- the perimeter of Analyte P -- continuation -- it is supported pivotable. This rotation is driven with the stand driving gear 13. With the two-dimensional data collector 12, it integrates with the output of the two-dimensional-array detector 12 in time, and it is digitized and are collected as projection data. The stand driving gear 13 is controlled by the stand control unit 33, and the berth driving gear 20 is controlled for a high-voltage transformer assembly 4 by the high-voltage control unit 5 at the berth control unit 34, respectively.
[0010] It is sent to the data pre-treatment equipment 31, and the projection data from the two-dimensional data collector 12 is at the data pretreatment section 311 first. After general pretreatment of Log conversion (logarithmic transformation) etc. is performed, the after [pretreatment] two-dimensional projection data storage section 312 memorizes. The slanting cross-section approximation projection data origination section 313 creates approximation projection data required to reconfigurate the image about a slanting cross section using the projection data after pretreatment. The image re-component 32 reconfigurates an image (slanting cross-section image) from the approximation projection data created in the slanting cross-section approximation projection data origination section 313. The so-called half reconstruction approach which can reconfigurate an image from the projection data for 180 degrees is adopted as this reconstruction processing. This tomogram data is sent and displayed on an image display device 37 through the main control section 36, and is sent to the image data storage 35, and is memorized. The main control section 36 controls the high-voltage control unit 5, the stand control unit 33, and the berth control unit 34, and performs helical scan.
[0011] Next, an operation of this example is explained. In addition, the moving coordinate of explanation which moves with Analyte P is specified for convenience. In this moving coordinate, by helical scan, the X line source 10 will move a spiral orbit, as shown in drawing 3 (a). In an actual motion, while the X line source 10 and the two-dimensional-array detector 11 carry out continuation rotation, Analyte P moves to an one direction on a berth 2. Here, the jargon treated by the following explanation is defined.

- Actual existence projection data; projection data on the X-ray pass (it is called a virtual path) which is needed in order to reconfigurate the image of the projection data and the virtual projection data; reconstruction side of the actual existence actually collected with each detector of the two-dimensional-array detector 11 (here, it defines as a slanting cross section) and which is included ideal, i.e., the reconstruction side concerned. In helical scan, such virtual projection data does not exist really except for some exceptions.
- Approximation projection data; projection data on the X-ray pass in X-ray beam FX most approximated to a virtual path (it is called approximation pass). In addition, this approximation projection data may not exist really by existing really as actual existence projection data. When it does not exist really, it creates with interpolation (distance interpolation) from the actual existence projection data near approximation pass. Approximation projection data is created by every [of the X-ray from the X line source 10 / one / every] radiation direction (a definition is given as whenever [fan interior angle]) about angle of rotation of each of the X line source 10.

[0012] In addition, two or more X-ray pass required for reconstruction cannot define the flat surface of one sheet in helical scan. One of the descriptions of this example sets up the slanting cross section (reconstruction side) which inclines to the Z-axis to the X-ray pass group for half-rotation of the X line source 10, and it is to reconfigurate an image using the projection data for this half-rotation (refer to drawing 3 (b)). Thereby, there are few gaps with the curve side and reconstruction side which are drawn by the X-ray pass group for half-rotation, and they can reconfigurate an image with little artifact. Furthermore, the description of this example is setting up the slanting cross section where the artifact's makes min the min of gaps, i.e., the above-mentioned amount, to the X-ray pass group for half-rotation, and setting approximation pass. Approximation pass is specified by Z location angle of rotation of the X line source 10, and whenever [fan interior angle].

[0013] The volume data of a three dimension are obtained by repeating reconstruction processing, shifting a slanting cross section little by little in accordance with the spiral orbit of the X line source 10. Spatial resolving power changes according to the migration pitch of this slanting cross section. For example, change of the slanting cross section which it shifted 90 degrees at a time to drawing 4 is shown. According to this approach, a minute (it changes according to a migration pitch) of an image can be reconfigurated, for example by one rotation several times of the helical CT of the single slice put in practical use until now or a dual slice.

[0014] It explains below at a detail.
- Although the slanting cross section mentioned above what is specified in approximation by the X-ray pass group which moves while 180 degrees of X line sources 10 rotate about a setup of the virtual flat surface (slanting cross section) which should be reconfigurated, it is necessary to specify the virtual flat surface used as the min of the above-mentioned amount of gaps approximated most. The angle of rotation of the X line source 10 and the axis of ordinate are expressed [the spiral orbit of the X line source 10 (source)] for the axis of abscissa as a Z coordinate to drawing 6 . The spiral orbit of the X line source 10 is shown on this graph by the primary straight line fsource passing through a zero. On the other hand, a virtual flat surface is the sign curve fplane on this graph. It is shown by carrying out. Here, 180 degree+ fan include-angle 2A, a part for i.e., ** (90degree+A), is given as a view required for half reconstruction focusing on 0 degree. fsource and fplane It will be easily understood that the amount of gaps of a virtual flat surface and the curve side drawn by the X-ray pass group for half-rotation of the spiral orbit of the X line source 10 is small, so that the integral of a difference is small.

[0015] For example, if fan include-angle 2A=50 degree, it will become 90 degree+A=115 degree, but when the ratio of the tilt angle (a graph top is equivalent to the inclination in 0 times of the sign curve fplane) of a virtual flat surface and the inclination of fsource according to the relative-displacement rate of the berth 2 to rotation of the X line source 10 at the time of helical scan is 1.095 at this time, the difference d1 and d2 of both functions is mostly in agreement. That is, the maximum (|d1-d2|) of the absolute value of the difference of both functions is able to specify few optimal virtual flat surfaces of the artifact most by setting up a virtual flat surface so that it may become min. Thus, the approach of setting up a virtual flat surface so that the root mean square of the difference of both functions other than the approach based on the maximum of the absolute value of the difference of both functions may serve as min may be adopted. Of course, it is not limited to such

two approaches.
[0016] - The virtual path contained in a virtual flat surface is rare, therefore virtual projection data hardly exists as actual existence projection data so that I may be understood with reference to drawing 6 about a setup of approximation pass. Therefore, the approximation pass nearest to the virtual path in a flabellate form X-ray beam with fixed thickness is set. Here, when 0 degree is considered whenever [fan interior angle], the pass on the virtual flat surface which passes along the core (it is the same as the center of rotation of the X line source 10) of FOV (Field of View) like drawing 7 is a virtual path. On the other hand, approximation pass is given as pass which passes along a FOV core from the X line source 10. Let the actual existence projection data which passes along this approximation pass be approximation projection data about 0 degree whenever [fan interior angle]. If actual existence projection data existence is not recognized through this approximation pass, approximation projection data is created with interpolation from two actual existence projection data of the channels A and B nearest to the intersection of the approximation pass and a detector side concerned. A thick wire shows notionally change of the intersection group of the detection side of approximation pass to change of angle of rotation to drawing 5 . Two kinds of examples are offered about the setting approach of approximation pass.
[0017] (1) The setting approach of the 1st approximation pass (refer to drawing 8 (a))
By this approach, when it sees about an certain angle of rotation of the X line source 10, the intersection to the detection side top of approximation pass will be drawn "in a straight line" with change which is whenever [fan interior angle]. As mentioned above, 0-degree approximation pass is set whenever [fan interior angle] so that a virtual flat surface may be intersected focusing on FOV. An approximation pass group is set up so that the slightly flat ellipse of the virtual flat surface where the intersection of the approximation pass of whenever [other fan interior angle] and a virtual flat surface made the radius from the X line source 10 to the FOV core the core [the X line source 10] may be drawn. It is mentioned that whenever [of actual count / complicated] is small as for the advantage of this approach. All approximation pass required to reconfigurate the tomogram for one sheet by this approach to drawing 9 is shown. In addition, the angle of rotation zeta of the X line source 10 expresses with drawing 9 the core of half-rotation that not an include angle but the X line source 10 uses for reconstruction absolutely, as 0 degree, and the Z location rho makes a zero the center position of the successive range where a berth 2 moves while the X line source 10 half-rotates. It expresses with the distance (mm) from a zero, and is used widely and shown to change of migration of angle of rotation of the X line source 10, and Z location of a detector. By drawing 9 , while the X line source 10 half-rotates, it is indicated that a berth 2 moves 40mm. The angle of rotation zeta of the X line source 10 of the view of drawing 9 is 0 degree, the Z location rho of approximation pass in case alpha is 0 degree whenever [fan interior angle] is projection data of 0, and, probably, this usually exists really. Of course, if the actual existence pass of this Z location rho does not exist really, approximation projection data is created by interpolation from the actual existence projection data on two pass nearest to the approximation pass concerned.
[0018] (2) The setting approach of the 2nd approximation pass (refer to drawing 8 (b)).
This approach sets approximation pass so that a virtual flat surface may be crossed at the core of approximation pass. The intersection of such an approximation pass and a virtual flat surface draws few ellipses which the cylinder which extended the periphery on XY side which makes a diameter the X line source 10 and distance based on FOV(s) to Z shaft orientations, and the slanting cross section which is a virtual flat surface intersect. Of course, if the actual existence projection data of this approximation pass does not exist, as mentioned above, it creates with interpolation.
[0019] As mentioned above, it is not restrained by a setup of approximation pass, and two examples which could otherwise consider the modification and were raised here although two examples of creation of approximation projection data were given when put in another way. In addition, about interpolation, for every combination of angle of rotation and whenever [fan interior angle], it is made unnecessary [the count process of a interpolation multiplier] in creation of approximation projection data to ask for a interpolation multiplier beforehand, and it can be said from a viewpoint of mitigation of computational complexity that it is effective. Furthermore, a setup of a virtual flat surface and approximation pass can take, and an employment top can be altogether woven into the above-mentioned interpolation multiplier also about the direction.

[0020] Next, an example is given and explained. Here, the distance from 600mm and the X line source 10 to the two-dimensional-array detector 11 is assumed to be 1.1m, and a fan include angle is assumed to be 50 degrees for the radius of gyration of the X line source 10. At this time, FOV (reconstruction field) is 600xsin (50 degrees/2). It is set to about 250mm. moreover, if the two-dimensional-array detector 11 is put in another way nine channels to a Z direction (the slice direction), a one dimensional array detector will assume that it is 9 successive-installation ******** to a Z direction. Moreover, it is assumed that the one dimensional array detector is arranged with the row pitch (a row pitch is set to 2.57mm at this time) which is equivalent to 1.4mm spacing at a FOV core. Moreover, while the X line source 10 rotates one time, it is assumed that the movement magnitude of a berth 2 is 15mm. A gap of approximation pass within FOV at this time and the Z direction of a virtual flat surface can also estimate the plus direction and minus direction at about 0.41mm by count. Ejection of the approximation projection data from the storage section 312 is performed according to drawing 9 . Linearity distance interpolation may be used for interpolation processing, and it is risen. Any of the interpolation using a cosine function are sufficient. The need range of the data on the two-dimensional-array detector 11 can be estimated at double sign 10.18mm, and enters into existence range 2.57mmx4=10.28mm of a detector 11. Activation slice thickness will be more thickly set to about 2mm to width of face of 1.4mm of the channel based on FOV(s), in order that interpolation processing may enter at the time of approximation projection data origination. At this time, error 0.41mm of a previous Z direction is a small error suitably, and is understood by not coming to generate the big artifact in image quality.
[0021] Next, image reconstruction is explained. An image will be obtained if two-dimensional half image reconstruction is performed from approximation projection data. As actual processing, it is good only by performing two-dimensional half reconstruction as usual to the approximation projection data obtained as mentioned above. Although an opposed beam will be obtained a little if the data for a 180 degree + fan include angle are used at this time, averaging of these both may be carried out and one side may be chosen. Of course, data are acquired in a little larger include-angle range, and it is good as for a method of "being weighting ****** smoothly" in an opposed beam.
[0022] By the way, that the system of coordinates of reconstruction should just reconfigurate about X perpendicular to a Z direction, and a Y-axis, although a reconstruction side has an inclination slightly by this, it is obtained as an image which looked at this from the Z direction. There is no need of restarting the two-dimensional coordinate within a virtual flat surface. Since the reconstruction side which continues as it may say that data from the first are collected by X and Y coordinate and being mentioned above is not parallel, it is thought that the direction with X and Y coordinate is easy to treat as three-dimension data on the contrary.
[0023] The above explanation has described collection of volume data focusing on acquisition of a single slice. What is necessary is just to shift a little half-rotation range required to reconfigurate the image of one sheet, in order to obtain volume data (refer to drawing 3 (a)). For example, what is necessary is to shift the half-rotation range in the pitch of 360 degrees / 8= 45 degrees, and just to set up a virtual flat surface between 1 rotations of the X line source 10, in wanting the image of eight sheets.
[0024] Now, the image obtained is not parallel even if it creates an image one by one in a pitch 45 degrees in accordance with the spiral orbit of the X line source 10. For this reason, although spatial resolving power changes in the XY direction, this is considered reflecting the spatial asymmetry of the spiral orbit of the X line source 10 from the first, and it can be said in that semantics that it is very natural.
[0025] Since a series of obtained images are un-parallel, it is necessary to start two-dimensional images of arbitration, such as an parallel cross section and a cross-section conversion image containing a music cross-section conversion image, mutually. What is necessary is just to compute each field according to this, since the location is given by the formula of P (zeta) mentioned later. Moreover, although the employment top with actual processing using this is the most convenient once it creates an parallel cross section mutually when performing three-dimension image processings, such as a surface display and projection image creation, it is good to raise precision to perform direct processing from a series of obtained un-parallel images.
[0026] It compares with a conventional method about helical CT and the dual slice helical CT which

performs the multi-slice of 2 slices. About the effectiveness of the speed and the acquisition time of first an image pick-up When he wanted the field which has the thickness for 10cm in helical CT in the example shown previously, for example as 2mm slice data, the berth was moved 2mm per rotation and 50 rotations needed to take a photograph. It is made to move 4mm per rotation, and 25 rotations are required of the thing of a dual slice. If this method is used, since a berth is moved 15mm per rotation, it will end with 7 rotation extent in the above-mentioned example of concrete count. Next, I will consider the error of a projection beam's in FOV at time of reconstruction existence location. although this method is the approximation technique and an error exists -- the above -- like the example shown in the concrete example of count, sufficient precision can be given under suitable conditions. Also in the conventional helical CT, interpolation processing with contiguous data is performed, and even if it uses this method, it can be said that it can perform in an error comparable as a conventional method.

[0027] Drawing 10 is a flow chart which shows the flow of a series of processings from data collection to reconstruction, and shows a certain slanting cross section to drawing 11 . When setting the inclination of h [mm] and a virtual flat surface to kappa for the berth movement magnitude per rotation, The slanting cross section P (zeta) centering on the location which carried out zetaradian rotation, i.e., (zetah/2pi), the location of [mm], is P(zeta) = {(x y, z) z= (zetah / 2pi)+[(x y)](-sin zeta, coszeta) xtan kappa}.

It is come out and given. However, "-" expresses an inner product.

[0028] Here, if it is the angle of rotation beta of the X line source 10, whenever [fan interior angle / alpha], and the location rho of a Z direction, this approximation projection data shall be expressed as R (beta, alpha, rho). In fact, since projection data is obtained discretely, it is expressed as R (l (**beta), m (**alpha), n (**rho)). In addition, it is m=-M / 2 - +M/2, and n=-N / 2 - +L/2.

[0029] Since the X line source 10 carries out number rotation by helical scan, beta becomes wide range. This range I is set to I=LL1 - LL2. Moreover, range corresponding to -(pi/2+A) - (pi/2+A) at the real include angle which is the range required for half reconstruction - It is described as L / 2 - +L/2.

[0030] Now, the X line source 10 will consider reconstruction of the slanting cross section in the location which only zeta rotated. The Z location rho on the detector of the approximation pass of all approximation projection data required in order to reconfigurate the reconstruction image H of this slanting cross section (zeta) is given as rho (beta, alpha) as a function of beta and alpha.

[0031] H (zeta) is obtained as follows.

(STEP1) Approximation projection data R (zeta, beta, alpha) of a slanting cross section is R(zeta, beta, alpha) =R (zeta+beta, alpha, rho (beta, alpha)).

It is come out and created. At this time, it is zeta+beta=(I (zeta)) - (**zeta).

alpha=(m (zeta)) - (**alpha)

(n-1) When -(**rho) <=rho(beta, alpha) <n- (**rho), it is R (I(zeta) - (**zeta), m(zeta) - (**alpha), alpha, - (n-1) (**rho)) in fact.

R (I(zeta) - (**zeta), m(zeta) - (**alpha), alpha, n- (**rho))

Approximation projection data is created by interpolation processing from the actual existence projection data of two **.

(STEP2) Image H (zeta) is reconfigurated with a predetermined half reconstruction algorithm in the direction which only zeta rotated using approximation projection data R (zeta, beta, alpha).

[0032] In addition, as soon as reconstruction of an image required one by one during activation of helical scan is completed, one by one, as long as the storage capacity of the storage section 312 is large enough, it may be made to eliminate approximation projection data R, and to perform reconstruction processing after helical scan termination.

[0033] This invention cannot be limited to the example mentioned above, but can deform variously, and can be carried out. Sequential explanation of the modification is given below.

(1) Resolution can be raised by using together concomitant use this invention of a shift device, and a shift device. For example, the juniper the radius of gyration of the X line source 10 "was shifted" so that 600mm of an above-mentioned example might be set to two thirds of 400mm. This is interlocked with and slice thickness also makes 10mm of 2/3 also set movement magnitude of the berth per X line source 101 rotation to two thirds from 15mm in this method. Although it is not

necessary to make it not necessarily interlock, it is most efficient for the whole slice direction ****** target to raise resolution.

[0034] (2) It was what is referred to as that 180-degree rotation part extent of the spiral orbit of the X line source 10 will extract and bring together the projection data near this helical slanting cross section in one flat surface paying attention to being contained in approximation, and the fundamental idea of use this invention of a partial angle reconstruction method will perform the usual two-dimensional half reconstruction. If the ** office of the spiral orbit is carried out to a part, the part approximation will become good. A partial angle reconstruction method is used together as a modification of this method. Since location-approximation of the spiral orbit of the X line source 10 and a virtual flat surface will become very good if this method is used, an image can be obtained even if the virtual flat surface has whenever [tilt-angle] further. Therefore, "the fan include angle of the slice direction" can be enlarged and the effectiveness of photography improves further.

[0035] (3) the correspondence to inverse rotation (berth hard flow migration) -- in actual equipment, the migration direction of a berth may be used in both directions of the direction inserted in CT stand, and the direction to pull out. Moreover, the hand of cut of the X line source 10 itself can consider two kinds of inverse rotation ******. in this case -- since the relative screw motion of the X line source 10 over analyte is symmetrical with a mirror image -- the above-mentioned data processing (creation of approximation projection data, coordinate of a back projection operation, etc.) -- all are considered as the mirror image symmetry.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The block diagram of CT concerning this example.
[Drawing 2] The block diagram of the data pre-treatment equipment of drawing 1 .
[Drawing 3] Drawing showing the spiral orbit of X line source in helical scan.
[Drawing 4] Drawing showing change of the slanting cross section which it shifted 90 degrees at a time.
[Drawing 5] The conceptual diagram showing change of the intersection group of the detection side of approximation pass to change of angle of rotation.
[Drawing 6] Drawing showing the spiral orbit of X line source, and the equipment of a virtual flat surface.
[Drawing 7] Drawing showing a 0-degree virtual path and approximation pass whenever [fan interior angle].
[Drawing 8] The explanatory view of the setting approach of approximation pass.
[Drawing 9] Drawing showing Z location of all approximation pass required to reconfigurate the tomogram for one sheet.
[Drawing 10] The flow chart which shows the flow of a series of processings from data collection to reconstruction.
[Drawing 11] Drawing showing the slanting cross section corresponding to drawing 10 .
[Description of Notations]
1 -- Stand 2 [4 / 10 / 3 / 31 / 33 / 35 / 37 -- Image display device. / -- Image data storage 36 -- Main control unit / -- A stand control unit, 34 -- Berth control unit / -- A data pre-treatment equipment, 32 -- Image re-component / -- A stand driving gear, 20 -- Berth driving gear / -- X line source 11 -- Two-dimensional-array detector / -- A high-voltage transformer assembly 5 -- High-voltage control unit] -- A berth, 3 -- Console

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[Translation done.]